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(1) **EP 1 026 878 A2**

(12)

EUROPEAN PATENT APPLICATION

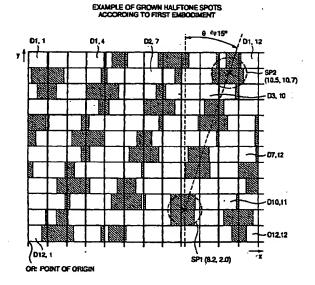
(43) Date of publication: 09.08.2000 Bulletin 2000/32

(51) Int. Cl.⁷: **H04N 1/405**, H04N 1/52

- (21) Application number: 00300829.9
- (22) Date of filing: 03.02.2000
- (84) Designated Contracting States:
 AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
 MC NL PT SE
 Designated Extension States:
 AL LT LV MK RO SI
- (30) Priority: 05.02.1999 JP 2866699
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- (54) Color electrophotographic apparatus and method of processing an image produced thereby
- (57) An image reproduction engine which causes toner to adhere to a development region of certain area located at a certain position within dots according to image reproduction data is utilized for image processing, wherein a halftone is expressed by means of halftone spots formed from a plurality of dots. The centroid of the halftone spot formed from a single dot or a plurality of adjacent dots is shifted from the center of the dot to an arbitrary position, thus achieving desired screen angles or desired pitches of halftone spots. As a result, screen angles related to an irrational tangent can be realized, and the pitches of halftone spots of a plurality of color screens can also be made uniform.

FIG. 4



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BACKGROUND OF THE INVENTION

1. Field of the Invention of the sier seamen in entire

[0001] The present invention relates to a color electrophotographic apparatus, which performs halftoning operations through use of halftone spots formed by a plurality of dots a method of processing an image promote duced by the color photographic apparatus, and a recording medium having recorded thereon a program 100 to be used for image processing in this specification, and the word "dot" implies "pixel" defined as a unit cell invigor electrophotographic apparatuses; specification is based on Japa-1000 nese Patent Application No. Hei. 11-28666; which is used incorporated herein by reference and parasonal electroporated and paraso

dent introconnection as particular deposition in ehr

ு நராகளை கடிக்கலத்த சாறுவழுரிறில், base நக்கிய ப 2. Description of-the Related/Art அலில் volugisme na. est **20**

[0003] collinean electrophotographic apparatus, such 1807 as a color printer or a color copier a color image is as of reproduced by utilization of cyan toner, magenta, toner, on ic. yellow toner, and black toner. Particularly, among color. 25, printers; some page printers-which forms a latent image and on a photosensitive drum by utilization of a laser beam. *ECC! develop, the latent-image by: use of charged tonerpand parts transfer an image formed from the thus developed tonerv gri onto transfer paper can change an area to be exposed 6:30; by the laser, beam within as dot in various manners is a to Thus, even when the number of dots persunit area is to he small, those page printers; can reproduce a color, imagens of with high resolution and high gradation; for bereab to seigns [0004] right such a color-electrophotographic appara eless tus, audithering method has been widely sutilized as autorio binary-coding method to be used for iteoroducing the neo halftone of a gray-scale image. According to the dither 3703 ing methodaby reference to conversion tables which are autor called dither matrices or threshold value matrices and a 40 which adefines the acomespondence between shalftone as val data and image production/data; a determination is assi made as to whether color spot is displayed in each dot visit or note: A dot is: ON! when color spot is displayed and is as "OFF" when color spot is not displayed (Halftone spots 545) are produced by one dot or some adjacent dots turning(lape) "ON", and halftones of the imagescare reproduced on #106; the basis of the sizes of halftone spots: volo included and si [0005] Dots are arranged in the direction of primary: 000 scanning in which:a laser beam is moved for scanning 0.66 (hereinafter, referred to simply as a "primary-scanning size direction") and in the direction of secondary scanning in white which transfer paper is fed (hereinafter referred to sime a det ply as a "secondary-scanning direction"). As some dots to a become "ON";and thus form the "core of the growth" of 551 halftone spots. As the gray-scale level of the halftone stab data is increased further; the number of "ON" adots is the eventually increased, thus gradually enlarging the size

of the halftone spots നാട്ടി. വാന്നു വേട്ടില് മാന് ഉന്നട

[0006] sa cFIG:10shows the combination of the angle of the combination of the combinatio a cyan screen, the angle of a magenta screen, the angle and of a yellow screen, and the angle of black screen, which has has conventionally been used in wide applications of industrial printing systems. As shown in the drawing, according to the conventional technique, the anales of four color screens are set; specifically, the angle of the yellow (Y) screen is set to 0°; the angle of the cyan (C) screen [or the angle of the magenta (M) screen] is set to 15°; the angle of the black (K) screen is set to 45°; and the angle of the magenta (M) screen [or the angle of the cyan (C) screenl is set to 75° [0007] It is also known that, if the screen angles of the halftone spots are shifted in order to prevent chromatic, imisregistration; a37 so-called imoiré fpattern (35), appears. It has empirically been acknowledged that a shift of angle of about 30° between two color screens is optimal for increasing the spatial frequency of the moiré pattern; to thereby render the moiré pattern inconspicu-orne ous. Yellow is less noticeable to the human eye. Therefore, the other 3 color screens (C,M,K) are set shifted be from each other by:30% Further, the angle of the black screen; which is most noticeable to the human eye; is 300 set to:45% so:aspbe most distant/from:a longitudinal angle of 0% and arhorizontal angle of 90%, which are easily recognized by the humanreye. The angle of the cyan a " screen is set to 15% and the angle of the magentages screen is set to 75° sithe angle of the yellow screen is a list set to 0°. Although the yellow screen is set to the longitudinal direction or the horizontal direction that are most and noticeable to the human eye; the yellow screen does not well a become greatly-noticeable because vellow is least med noticeableito:the:human eye.seve work is to see matter see to all [0008] As mentioned above, the industrial printing Page system is designed so as to prevent a moiré pattern by setting the magenta or cyan screen to an angle of 15° or 3500 75° and rotating the color screens Since the color screens are only rotated, exactly as they are; the pitche among-halftone spots is maintained uniform throughout 1500 the 4 colors down in uning askuarly to hedmun lent by execution [0009] 1. Initian electrophotographic apparatus utilizing 1975 a laser beam, the pattern of dots, which can be developed by an engine for developing an actual image one the basis of image reproduction data; is limited to the cold direction of primary scanning in which a laser beam is actuated for scanning, as well as to the direction of secondary scanning in which paper is fed. Unlike the industrial printing system; the electrophotographic apparatus is incapable of rotating the color-screens to arbitrary and angles: Accordingly, in the electrophotographic apparatus, desired screen angles are achieved by shifting the 1910. positions of the dither matrices to be used for the dithering method in primary or secondary scanning direction. or by changing the data in the conversion table, as 1978 required.

[0010] FIG. 2 is an illustration for describing a conventional method of determining screen angles in dith-

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ering method. In this example, dither matrices:40, leach: ... measuring m x m, are shifted from one another so as to. correspond to image, data, thus achieving asscreen. angle θ; i.e. tan:θ = b/a. In a more specific example ::! shown in FIG. 2, dither matrices 40 are shifted such that 2.51 in a horizontal row of dither matrices 40 peach dither and matrix 40 by a given amount, such that after four shifts ::: the last dither in the row is vertically shifted by and a amount corresponding to the height of one dither matrix. 10 40. Therefore, we have tan θ = 1/4. A dither matrix 42 designatedaby broken lines comprises par plurality of dither matrices 40. It is possible to determine the screen (200 angle at an arbitrary value with higher degree of free condom by means of such a large dither matrix 42. 1 19.37 515 [0011] SLEA screen angle of a 15% for magenta and a Jam. screen angle of \$50 for cyan, which are deemed to conside tributed to the best picture quality in the printing indus- if its try, are related to an irrational tangent (i.e. par tangent of ... which is an irrational number): Angles related to the irra-1120 tional tangent cannot be reproduced, so long as estimiliate ited number of dots/arranged in both the direction of enoprimary, scanning, and the direction of Geoondairy, scan- area? ning are utilized. For this season, in the conventional and electrophotographic napparatus; the magenta iscreent 125 and the cyan screen are set to angles which are related by as ily reenal dangeritf and the fartenation of the time of time of the time of time of the time of the time of time of the time of time o integers), and @ = 15° and @ = 75° are not related to the error rational; tangent); and close to an angle of 15° and an eros ast to 0°. Aithcugh the validay screen is set to the 75,70 eigns [0012] ~ in (Anotherno) conceivable in papproached toward niput selecting anglesewhich; are related tootherrational tansource gent and close to \$5° and \$75° is to increase the size of post the dither matrices 42. However, the number of dots persion unit area/which the engine can process is as small association e.g., 600r.dpis(dots/per finch): df-the size/efidhe idithereis/s matrices is increased shalftone spot pitch increases and linea screen frequency is aliminished. Further an increase in 1997 the size of dither matrices also results in an increase i the number of corresponding required stables. Such an order increase in the number of y tables in turn involves an - sat increase; in the wolume of apprecording medium for the recording the conversion tables. Eventually, the cost of asile the electrophotographic apparatuses increased: has we beauti [0013] in oilnea case where halftone spots are formedd 45; by utilization; of the dots fixedly arranged in both the wo direction of primary scanning of the laser beam fi.e., the subst primary-scanning direction) and the direction of second-sary scanning of the same (he) the secondary-scanning; at direction); the pitch between halftone spots among they 50. color sergens of different angles cannot be made uniform. Even sing this prespect, other electrophotographic and apparatus, encounters difficulty providing the same picture quality, as that provided by the industrial printing of the system: Jaide inclusive objetto i Problem go intanting 55;

SUMMARY OF THE INVENTION

An object of the present invention is to pro-[0014] vide an electrophotographic apparatus capable of achieving screen angles related to an irrational tangent. a method of processing an image produced by the electrophotographic apparatus, and a recording medium on which an image processing program is recorded with regard to a color electrophotographic apparatus which is in reproduces an image by utilization of halftone spots formed from a plurality of dots in which work with the health [0015] Stro Another object of the present invention is to provide an electrophotographic apparatus capable of -- " making uniform pitches of halftone spots in a screen 1996 compatible with a plurality of colors a method of the processing ran image aproduced by the electrophoto in the electrop graphic apparatus, and a recording medium on which an image processing program is recorded with regard to a color electrophotographic apparatus which reproduces an image by utilization of halftone spots formed. from a plurality of dots.

[0016] Still another object of the present invention is to achieve the objects through use of a reduced number 5 34 of conversion tables: "short neyon to not trailled it it men. In these [0017] 65 An image reproduction engine which causes it is. toner to adhere to/a development region of certain area located at a certain position within dots according to: 5 % image reproduction data is utilized for image processing, wherein a halftone is expressed by means of halftone spots formed from a plurality of dets. The centroid and of a halftone spot formed from a single dot of a plurality of adjacent dots can be shifted from the center of the dot to ansarbitrary (position) thus achieving desired, screen issue angles or desired dot pitches. As a result, screen angles related to an irrational tangent can be realized, and the pitches of halffone spots of a plurality of cologracreens can also be made uniformbe au est est boritere gribos, granist [0018] addition the case of an electrophotographic appa-pilities ratus which radiates a laser-beam onto a region of dots "" P" while being scanned in audiven direction; the present size invention enables the position and area where the laser to the beamsis radiated to the controllably changed to ran affile State trary positions and ranea sforaeachadota by-producing a would laser drive pulse signal according to image reproduction of acdata by means of pulse-width modulation (PWM) as The alle produced by one dor or sonle adiacent tots runteriuper [0019] partn order togreduserthe volume of conversion 300 tables which are provided within a controller of an elecs of the trophotographic apparatus omal driver of the thest and \$6000 which defines the icorrespondence, between halftone costs data and image reproduction data; the present invention (\$15)? utilizes an index-type conversion table. The conversion index-type conversion in table. table comprises a plurality of ytables defining the correspondence between halftone data and image reproduc- a 40 tion data and a pattern matrix which includes reference as a second data representing ytables telberreferred to so as to corporate a respondational matrix includingsal planality of dotsat By (4155) means of such a configuration, some of reference data 20% a

sets in the pattern matrix can be identical, and a single

 γ table can be referred to by a plurality of dots within the $m_{\rm eff}$ pattern matrix. [0020] to To achieve the objects of the present invention, the present invention provides a color electropho-11.5% tographic apparatus, which, reproduces an image by that utilization of a plurality of color toners and by expressing halftone of each color through use of halftone spots formed from a plurality of dots, the apparatus comprises: ing: a halftone processing section which is provided with a 40 halftone-data for respective colors and which treproduces the image reproduction data corresponding to the cost dots on the basis of the halftone data by reference to a 3003 conversion table defining the correspondence between the the halftone data prepared so as to correspond to the at 15 dots and image reproduction data; and an image reproduction engine which is provided with a drive signal cor-, a of responding to the image reproduction data and which are causes the toners to adhere to a development region with whose area and location correspond to the image reproduction data, within the dots, wherein the halftone 2 - 6 processing section prepares the image reproduction condata to be used for changing the angle of one-color-nips screen of the plurality of color screens to substantially much [0021] A Further to achieve the objects the present to the invention, provides a color electrophotographic apparations tus which reproduces an image by utilization of a plural- (AO ity of color toners and by expressing halftone of each this color through use of halftone spots formed from a plural at 30 ity of dots, the apparatus comprising a halftone room processing section which is provided with halftone data that for respective-colors and which reproduces the image of entireproduction data corresponding to the dots on the bas basis of the halftone data by reference to a conversion at 1950 table defining the correspondence between the halftone 2001 data prepared sonas to correspond to the dots and toos image reproduction data and an image reproduction odi engine which is provided with a drive signal correspond- abla ing to the image reproduction data and which causes 40: the toners to adhere to a development region whose what area and location correspond to the image reproduction and data, within the dots, whereing the halftone processing and section prepares the image reproduction data to be to a used for making the distances among the centers of the # 951 halftone spots, of the plurality of colors substantially and นักเการ seasy Timeration, าก วานกฤษ สถางลา or 所造 **µlaupe** [0022] The present binvention salso provides as the recording medium which reserves an image processing are seen method for use with the foregoing electrophotographic." (50) apparatus Fand (approgram (used) for effecting timage (if the processing.enatheritic can next lesso sint of thousand at a new [0023] Features and advantages of the inventions 160 will be evident from the following detailed description of a 1991 the preferred embodiments described in conjunction (55) with the attached drawings; such the relation of the PRODE

BRIEF DESCRIPTION OF THE DRAWINGS.

grienegricane habe in la este la tere, est boue [0024] and In the accompanying drawings: The second Second From Simble Tourney of the Exercise test many of the content FIG. 1 is an illustration showing the combination of the angle of a cyan screen, the angle of a magenta" screen, the angle of a yellow screen, and the angle of black screen; which has conventionally been used in wide applications of industrial printing sys-U 18 1 11 110 tems;ខណ្ឌ ខុស - បស្គ្រា 💢 🦿 😥 FIG. 2 is an illustration for describing a conventional method of determining screen angles; FIG. 3 is an illustration showing an example of halftone spot according to the first embodiment of the present invention of the cape of 10 cm. All FIG. 4 is an illustration showing an example of a . . . halftone spot which is formed on the basis of the basis foregoing principle and is grown according to the first embodiment; and its bereiter of the role of the con-FIG. 5 is schematic representation showing a conversion table used in the first embodiment; and specific FIG. 6:is an illustration showing an example of the pattern matrix according to the first embodiment; 2,350.5 FIG: 7: is: ;a :diagrammatic: representation: of :an : -example of the y table according to the first embod-was iment; is a confirmation under the following the major of the confirmation of the conf FIG: 8 is an illustration showing index-type conversion tables according to a second embodiment of

FIG. ::10::shows::an::example:of:fialftone-spots that have been grown according to the second embodiment; to specific entimost tremat apigos anumos eval est FIG. 1:1cis a schematic diagram showing the configuration of an electrophotographic system; and. the testing PIG: 12 is:a schematic diagram showing another -configuration of the electrophotographic system. on in the termes and service of an order of the camer and the camer.

DETAILED DESCRIPTION OF THE PREFERRED

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es. FIG. 9 is an illustration showing an example of a lent

's treat areason, as designated by A sawen in he Embodiments of the present invention will be [0025]described hereinbelow by reference to the accompanying drawings. However, the illustrated embodiments: shall not limit the technological scope of the invention. FIG. 3 shows an example of a halftone spot spot [0026] according to the first embodiment of the present invention. In this example, a single halftone spot SP is produced by formation of a development region designated. 30 as a shaded area, swithin dots D1 to D6 produced at; 1943 e.g., 600 dpio.Formation.of the@halftone spot: will be 127 described by reference to electrophotographic system in which a laser diode is activated on the basis of image [3]. reproduction data in accordance with a drive pulse modulated by a pulse-width modulation method, to thereby part mendicumental in effetive medivani, metosa y ittalicandi radiate a resultant laser beam. Compension i Ali

entiner i la bende d'ambio el crimi marental.

[0027]

The laser beam is radiated onto the dot D1

such that toner adheres to a region encompassing approximately the rightmost one-fourth of the idot (here-2.10) inafter called "rightmost one-fourth region"). The diameter of the laser beam is equal to; e.g., the longitudinal length of the dot, and the laser beam is radiated; onto a: desired region while being scanned in the transverse. direction of FIG. 3. Accordingly, in the case of the dot D1, the drive pulse for driving the laser is imparted with a timing and a width corresponding to approximately the rightmost one-fourth region. The development position can be controlled by controlling the timing, and the area of development can be controlled by controlling the pulse widthmy line kee tast aft or pulbage and also also if [0028] A dot D2 is adjacent to the dot D1) and the: 15 laser beam is radiated onto a region encompassing approximately the leftmost one-tenth of the dot D2. The development region of predetermined width is realized by connection of the irradiated region of the adjacent dot D1:to: the irradiated region of the dot: D2.7 The entirety of a dot D3 is exposed to the laser beam. The laser-beam is radiated onto a region encompassing approximately the leftmost two-thirds of an adjacent deta D4. As a result, a wide development region is formed by connection of the irradiated region of the dot 03 to the irradiated region of the dot D4. Similarly, the laser beam: is radiated onto a region encompassing approximately. the rightmost one-half of a dot D5, and the laser beamis radiated onto a region encompassing approximately: the leftmost:one-fourth;region ofra dot D6b යන් කණ වයි. [0029] 65"The/halftone/spot (SP) shownxinaFIG(#35isa characterized in that the development region formed: from the dots D1 and D2 is narrower than the development-region-formed from the dots D5 and D6 and that the development region formed from the adjacent dots: 35 D1 and D2, the development region formed from the adjacent dots D3 and D4pand; the development region. formed from the adjacent dots 05 and 06 are shifted leftward. As a result, the centroid of the halftone spot SP. formed from the dots D1 to D6 (i.e., the center of the halftone spot SP) is placed in a position shifted slightly from the center of the dots D3 to D6 in an upward and 2005 leftward direction, as designated by X shown in the Each tiding of the present invertions of any aligniwarb [0030] softman engine for reproducing an image pro-11345. duced: by an electrophotographic apparatus in which a drum is electrified; by exposure to a laser; beam and 1511; toner; is, adhered onto the thus-electrified, drum, even if. [65] the laser beam-is; radiated/onto-the regions such as the those shown in FIG. 3, the halftone spot-SP to be finally 150 reproduced becomes impressounded than the shaded region/shown in FIG: 3; by means of the shape of the £ 15 laser beam or the adhering-characteristic of toner. The center of the halftone spot can be placed at an arbitrary . See position without regard to arrangement of dots by set- 55 ting the positions and areas within dots to be exposed to the laser beam, as required to the first to the laser beam, as required to the laser beam. [0031] As mentioned above, a development region EndA

of arbitrary-area can be produced at an arbitrary-location within a dot, by means of controlling the timing and "s" width of a pulse signal used for driving the laser. Utiliza tion of such a development method and formation of a 200 halftone spot-through use of development regions of a second plurality of dots enables controllable changing of the time position of the halftone spot to an arbitrary position. without regard to the pitch and arrangement of dots. Thus, the present invention enables formation of a halftone "spotkat \an. arbitrary (position and realization) of the screen angles relatedato antitrational tangent and arbi-2013 trary-pitch of the halftone spotstore on where the contribute [0032] FIG. 4 is an example of a halftone spot which is formed on the basis of the foregoing principle and is " grown according to the first embediment. FIG. 4 shows a plurality of halftone spots to be formed from dots $D_{1,1}^{-1}$ to D_{12,12} of a matrix pattern having 12 rows and 12 columns: As will be described later, a conversion table defining the correspondence between halftone data of dots and image reproduction data assumes the form of t a 12x12 matrixer interests about of throw office a stock [0033] Each halftone spot may be formed from fouradjacent dots; six adjacent dots; or from some other standard number of dots. In either case, the center of the halftone spot is set at a desired location without regard to the constant pitch or arrangement of dots. For example, when the horizontal direction with reference to the point of origin OR located at the lower left end is taken as the X axis and the vertical direction with reference to the same origin is taken as the Y-axis, the coordinates of a halftone spot SPT are set to (8.272:0), and the coordinates of a coordinate of a coordinate or a coordinate of a coordinate or a halftone:spot/SP2 are set to (10:5, 10:7). In this case, 12:19 the halftone spot SP41 is formed from four adjacent dots; and the and the halftone specisses is formed from nine adjacent? *** data noise unition a consense of elements of a conversion atom [0034] of A screen angle defined by the two halftone shall spots 8P12and SP2(i.e.) the angle of a line connecting 5190 the halftone spots) 48-4.84 with reference to the YES -axis. The screen angle is very close to an angle of 15% and between the two halftone spots-6P4 and SP2 is 9.0 dots 300 long. Since two halftone spots exist between the halftone spots SP1 and SP2, the pitch between the halftone at the spots-shown in FIGh 4 (lie) the linear distance between 1000 the halftone spots) assumes a pitch of 3:0 dots in the 1980 screen whose angle is 0°, realization of a pitch of 3.00 missis dots is easy. Therefore, the example screen of FIG. 4 can be used as a rotated ecreen of 0° screen with the 2003 same halftone spot pitch (3:0 dots): doldw mulce a ghic rubet [0035] rue in the same manner de mentioned previously, the screen angles of 15% and 45% shown in FIG: 10% 10% can be realized. In this case, the pitch of halftone spots can be can also be set to a value of 3.0 dots; in the same manner as in the previous example of FIG\$4; month example of FIG\$4; [0036] *** FIG. 5 is schematic representation showing 3 5 13 a conversion table used in the first embodiment. The trans conversion table is ordinarily stored in a halftone processing section provided within an internal controller

of an electrophotographic apparatus. Image data shown ".....

in FIG. 5(A) comprise halftone data for respective colors and corresponding to dots. The halftone data may corre- .31 spond to a color space of RGB or to a color(space of CMYK. CMYK toners are commonly used in a color 5 electrophotographic apparatus. In such a case, the second image data comprise halftone data corresponding to Y, M, C, and K, respectively. (a particular of the Carl [0037] A pattern matrix shown in FIG. 5(B) and y 500 tables/shown/in:FIG.: 5(C)/are applied to such image... 10 data. In the first embodiment the pattern matrix consists of 12 rows by 12 columns. The ytable are prepared 12% for each element of the pattern matrix and identified by (2) reference number [ii] (i = 1.to 144). The pattern matrix in of a FIG. 5(B): contains the reference numbers to them sat table. For instance, given that the reference number of as is the pattern matrix corresponding to a dot: Profit mage: 25 data is 27,8 image reproduction datas corresponding to 365 the dot-Phare determined by reference ito: the yatable was whose reference number 27. Specifically, image repro-1020 duction data (an output value) corresponding to halftone 2003 data of image data (an input level) are read by reference in a to the y table corresponding to reference number 27:200 ent [0038] in coOn the basis of the image reproduction data nation determinedaby means tofathe conversion: table withe 25 engine utilizing a laser beam is provided with a laser of drive pulse signal/modulated by:the:pulse:width modulated by:the:pulse:width modulated lation/method, activates: a daser diode-in accordance state with the drive bulse, and radiates a taser beam onto a lexic photosensitive drum. Consequently, a laser beam is also radiated onto only a region of desired area on the left of 200. right side within and other adheres to they thus 1/0/9 irradiated region: The image reproduction data output 518 from the y table comprise data pertaining to whether the 2019 region to be irradiated is on the left or right side of the ulas dot, asswell as routse width data corresponding to the occuarea of the region to be irradiated.05 enigna en 88 noitoes [0039] 350 FIG::6 is an illustration showing an example 9 EV of the pattern matrix according to the first/embodiments to to As mentioned above, the patterns corresponds to a 546 matrix having 12 rows and 12 columns #Artotal for a 44 700 reference numbers (4 to 144) are assigned to elements 2001 of the matrix without involvement of an overlap of an involvement of an overlap, or and another [0040] teb :FIG::7/ils/andiagrammatic/representation of: 18/5 an example of the vitable according to the first embodi- 45 ment.:In this table!/input/levels of halftone data are 340 associated with outputs including image reproduction and data pertaining to whether the right or the left side of the dot is to be irradiated with a laser beam and data per- at altainingsto the extent to which the region is to be irradiated. (In the example shown in FIG) 7, the y table 19-00 assigned: to: reference number [4]* converts flow-level: [61]% input data into high-level output data and corresponds 1819 to a dot in the pattern matrix which grows when the could input level of the image data is comparatively low. The 7 55 table assigned to reference number "m" converts input?" data into coutput data so cas to be insproportion to the 222 input data and corresponds to a dot in the pattern matrix & Co

which grows when the input level of the image data is comparatively intermediate level. The y-table assigned to reference number op-corresponds to a dot which does not grow when the input level of image data is low but grows when the input level of the image data has reached a comparatively high level.

[0041] Gallothe first embodiment, y tables of 144 types are associated with the pattern matrix having 12 rows and 12 columns. Consequently, the y table shown in FIG. 7 also comprises y curves of 144 types.

[0042] An enormous pattern matrix such as

1000x1000 theoretically enables to realize screens with angles related to the irrational tangent or screen sets with equal halftone spot pitch among the screens of different angles. However, since a limitation is imposed on the resolution (dpi) of the engine, the electrophotographic apparatus such as a color page printer cannot utilize such a pattern matrix of enormous magnitude. Further if an attempt is made to achieve a resolution of about : 600 hdpi, itheli pitch / between shalftone / spots fill becomes too long (consequently, the screen frequency is reduced), so that the resolution of the resultant reproduced image is deteriorated drastically in the first in embodiment; the development region, which is located at a desired position within a dot and has a desired area; is controlled on the basis of the image reproduction data. As a result, even in the case of a small pattern matrix, the position of a halftone spot to grow is controllably set to an arbitrary position where the halftone spot is not limited by the dot pitch or the arrangement of dots, thus achieving screen angles related to the irrational tangent or a uniform pitch of halftone spots. a

[0043] As shown in FIGS: 5 through 7, there still exists a necessity-for providing γ tables of 144 types went in the case of the pattern matrix having 12 rows and 12 columns. Such a flarge number of γ tables require a large memory capacity. The large memory capacity of the present invention, the total number of γ tables is diminished by collecting, into a single table, γ tables assigned the same output for an input level 1.5 avoids 1.000.

[0045] FIG. 8 shows index-type conversion table according to the second embodiment. In contrast with the conversion table shown in FIG. 5, wherein individual γ tables are assigned to respective elements of the pattern matrix, an index of the γ table is assigned to respective elements of the pattern matrix. The γ table is sought by reference to an index table. Consequently, a single γ table can be shared among a plurality of elements of the pattern matrix, and the number of γ tables can be set to a small value independently of the pattern matrix.

[0046] As shown in FIG. 2; in a screen whose angle has a rational tangent (hereinafter called a "rational tangent screen"), dots appear, in the form of completely identical patterns, in positions spaced apart from one another by a given distance in the longitudinal direction and a given distance in the lateral direction. Accordingly, dots can be designated within a square matrix of finite

size without-involvement of errors. Further dots appear is a within the square matrix in the form of completely identification patterns. In this sense, the index-type conversion is advantageous in the case of the rational tangent screens of a square level of the latterns of the same of the sam

Strictly speaking halftone spots of the same (A.) [0047] pattern do not appear in the irrational tangent screen. In 1997 the second embodiment, 144 y tables are classified into a group of tables corresponding to halftone spots whose : : : right portions are development regions (i.e., regions to exposed to a laser beam) and another group of matrices . . . corresponding to halftone spots whose left portions are development regions. Of the plurality of thus classified as y-tables, by tables, with similar input-output correspond- at it. ence are collected. The thus-collected adjacent atables # :15 are assigned a single index. en to fict i not more sit [0048] FIG. 9 is an illustration showing an example : of a pattern matrix according to the segond embodiment. The pattern matrix shown in FIG: 9 represents in the state of th the form of a single pattern matrix; the pattern matrix of 20 shown, ia FIG: 8(B) and the index table shown in FIG. and a 8(C). In the pattern matrix shown in FIG. 6 in connection as a with the first embodiment adifferent by atables have suc assigned to all the elements of the matrix having 12.5% rows and 12 columns. In contrast, in the example shown 5, 25 in FIG. 9, y tables of 36 types are assigned to 144 ele-sent ments of the matrix having 12 rows and 12 columns: Numbers assigned to 144 elements shown in FIG. 9 Mark designate indices of the vitables. Accordingly, a tables vias' are understood to be assigned to the elements in an analog overlapping manner. For example, the natable assigned and number 1 is allocated to relements Dans Date Dans D_{3,10}, D_{7,12}, and D_{10,11} of the pattern matrix [0049] an Asimentioned above the total number of visite tables can be diminished by collecting y tables; assigned 15.35 to dots whose development regions are on the same that side and which output substantially the same value in and response to an input. Specifically, the adjacent γ tables 400of the atables shown in FIG. 7 are collected into a single is with Milesting, no a single racte, y lables assigned in quong FIG. 10 shows an example of halftone spots made that have been grown according to the second embodic according ment Eyep in this example the development regions of the formed in respective dots differ in position and area from some one dot to another. Consequently, the center coordinates nates of the grown halftone spot SR4 are (8.2, 2.0), and the center coordinates of the grown halftone spot SR2 are (10,5, 10,7). The halftone spots SP1 and SP2 can de be placed in the same positions as those shown in FIG. At this time, the screen angle θ assumes a value of , 50 about 15°, and the pitch of the halftone dot assumes a value of 3.0, as in the case of the example shown in FIG. 4. miles the life serves often out in agreement an interior ser [0051] As is evident from comparison between the example, shown, in FIG. 4 and the example shown in 55 FIG. 10, the dots $D_{1,1}$, $D_{1,4}$, $D_{2,7}$, $D_{3,10}$, $D_{7,12}$, and $C_{0,0}$ D_{10,11} shown in FIG. 4 correspond to dots whose rightside portions, are developed or remain substantially

undeveloped. In contrast, as a result of allocation of the # is single γ table to the corresponding dots shown in FIG2 10, the right-side portions of all the dots are developed to the same area.

FIG. 11 is a schematic diagram showing the Control configuration of an electrophotographic system! In this [2003] example rathost computer:50 produces image data (56: 48) comprising RGB halftone data (each data set including 1965) eight bits, and the halftone data: comprise a total of 24 : 11 bits). The RGB halftone data are delivered to an electrophotographic apparatus 60 such as a page printer. On 💆 🤭 the basis of supplied image data 56, the electrophotographic apparatus:60 reproduces a color image. The color electrophotographic apparatus 60 comprises a controller 62 which processes an image and supplies laser drive data 69 to an rengine, and an rengine 70 which reproduces an image according to the drive data 69. [0053] and application sprogram (52; 50.5) such as a aword processing program on a graphic tool; \$150 the host/computer 50 produces text data; graphic data; and all bit-map data or the like. The data sets produced by the application program 52 are rasterized by means of a 3550 electrophotographic papparatus.adrivera/software 54/1/16 installed in the host computer 50.2The thus-rasterized avia data sets are converted into the image data 56, each 1244 pixel or dot of which comprises respective RGB halftone (15) physicserumus rhimi. Consequently, a laser beattes attach [0054] #9. The relactiophotographic gapparatus#60 distances provided with an aunillustrated; built-in: microprocessor, 170% and the mioroprocessor sincombination with a control in the program installed therein constitutes a controller 62 man including casicolori; conversion itsection ::84] car halftone trest processing section: 66, and alpulse-width modulation: 300 section 68. The engine 70 te.g. ta laser driver 72 actions as a vates a Jaser diode 74 for drawing an image on the basis (CCO) of the drive data 69: Although the engine 70 comprises 9.49 to alphotosensitive drumpartransfer belt, and a drive see-19 6A tion, these elements are omitted from FIG. 1811 phivari sittam [0055] hamid hep color provided a least within the controller 62 converts RGB halftone data 569 to to that are supplied for each dot-into/CMYK halffore data() -0.99 10 which are complementary to the RGB data. In the kinds CMYK halftone data 10 ceach colomhalftone data set train comprises; 8; bits; and, a: maximum: of; 256; gray-scales; posse; The color conversion section 64 converts the RGB halfe and tone data 56 for each dot into the halftone data 10 for al 104. each plane dot of the respective GMYK colors. Consecration quently, the halftone processing section 66 is supplied and with the halftone data 19 corresponding to a plane dot of the last the respective colorate this turner level in principle of his arm recon-[0056] By reference to a previously-prepared conf. (). version table defining the correspondence between week halftone data and image reproduction data; the halftone a data processing section 66 produces, from the halftone data is see 10 for each dot, the image reproduction data 30 for each its are

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dot. The halftone processing section 66 produces the image reproduction data 30, which represent halftones; by utilization of; e.g., a multivalued dithering method. For example, through use of the conversion table comprising the pattern matrices and the mables shown in FIGS. 5 to 9, for each dot the halftone processing section 66 can produce the image reproduction data 30 which represent the right or left region, and the area of the region.

[0057] is all a preferred embodiment through use of the multivalued dithering method, a color printer of as low dot per inch as 600 dpi is possible to have a high resolution; by a high frequency screen with small spot pitch, and also halftone processing section:66 can set the center of a halftone spot at an arbitrary position regardless of the position of the dot. As a result birrational tangent screens can be realized; and the pitch of halftone spots among screens of different colors having different angles can be made substantially equal in

[0058] FIG. 12: is a schematic diagram showing another configuration of the electrophotographic system. This configuration corresponds to a modification of the system configuration shown in FIG::14:/in:the system shown in FIG. 12; a driver software 80 installed in the host computer 50 has a rasterization function 54. the color conversion function 64, and the halftone processing function:66. These functions:54:64pand:66 -01 are analogous to the functions of the elements assigned: the same reference numerals shown in FIG. 11:6 The image reproduction data 30 produced for leach color by: means of the halftone processing function 64 are supplied to the pulse-width modulation section 68 of the controller, 62 provided within the selectrophotographic apparatus: 60, such as:a page printer, where the data are converted into the desired drive data 69 and delivered to the engine 70t no bepuborger era stob add

[0059] distributed examples of the system bonfiguration shown in FIG. 12, the driver software 80 installed in the host computer 50 performs color conversion and halftone processing operations: thruther example shown in FIG. 1(1) the controller provided within the electrophotographic system performs color conversion and halftone processing operations. In the example shows in FIG. 12, the host computer 50 performs conversion and halftone processing operations infridemand exists for the electrophotographic apparatus 60 to be inexpensive, the price of the apparatus is required to be diminished by reducing the capability of the controller 62. In such a case, an effective measure is to implement the color conversion processing and other halftone processing, which are portions of the functions offered by the controller shown in FIG. 11, by means of the driver program installed in the host computer. In a case where the driver 80 performs halftone processing the storage medium having recorded thereon a program for causing 55 the computer to perform the foregoing halftone processing procedures is incorporated into the host computer.

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[0060] The Astrophotographic device capable of reproducing only admitted dot density to materialize screen angles substantially related to an irrational tangent with a small pitch of halftone spots and high resolution. Further, the all pitches of halftone spots of different color screens having different angles can be made substantially equal at a limited dot density.

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- 1. A color electrophotographic apparatus which reproduces an image by utilization of a plurality of color toners and by expressing halftone of each color through use of halftone spots formed from a plurality of dots/said apparatus/comprising: 400 100 and a new new social accession to the end of colors.
 - a halftone processing section which is provided with halftone data for crespective colors and cubic reproduces image reproduction data by reference to a conversion table defining a correspondence between the halftone data and image reproduction data; and
 - an image reproduction engine which is provided with a drive signal corresponding to the simage reproduction data to thereby cause the content to adhere to a development region of whose area and location correspond to the mage reproduction data, within the dots, if
 - wherein said halftone processing section prepares the image reproduction data to be used of store changing an angle of at least one color or screen of a plurality of color screens to substantially an angle related to an irrational tancogent; and of enems of menoi entre screens of page 1998.
- 2: A color electrophotographic apparatus according to claim 1; Wiferen said image reproduction engine radiates a speam to the development region to thereby sauses the toners to adhere to the development region, and
 - The image reproduction data comprise data pertaining to a position and an area to be exposed within the dot in a scanning direction of the beam. If the relation to when the control of the beam.
- A color electrophotographic apparatus according to claim?1, whierein the conversion table comprises parates of the distribution and parates.
 - a plurality of γ tables each defining the correspondence between the halftone data and the image reproduction data; and
 - a pattern matrix having reference data, which reference data show the y table to be referred to in response to the matrix having the plurality of dots.

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- 4. A color electrophotographic apparatus/according to 6 selaim 3 wherein a partial overlap exists in the reference ence data provided within the pattern matrix, and a servingle γ table is referred to by the plurality of dots within the pattern matrix. So the ence of the color of the ence of the e
- 5. A color electrophotographic apparatus which reproduces an image by utilization of a plurality of color toners and by expressing halftone of each color through use of halftone spots formed from a plurality of dots, said apparatus comprising:
 - THE ST NOTITION IN THE 10.000 4 a halftone processing section which is provided with, halftone, data of respective, colors and which reproduces the image reproduction data corresponding to the dots on the basis of the halftone data by reference to a conversion table defining a correspondence between the halfbris tone data and image reproduction data and to han image reproduction engine which is provided with a drive signal corresponding to the image reproduction data to thereby cause the toners to adhere to a development region ... whose area and location correspond to the image reproduction data, within the dots; inv wherein said halftone processing section prepares: the image reproduction data to be used for making distances among centroids of the halftone spots of the plurality of colors substanwherein said halfone processialsupe yllsiture.
- 6. A color such colorosts spant aft serial A color electrophotographic apparatus according to claim 5, wherein said image reproduction engine radiates care beam to the development in the development in the development region, and
- 7. A color electrophotographic apparatus according to claim 5, wherein the conversion table comprises
 - a plurality of γ tables each defining the correspondence between the halftone data and the image reproduction data; and inquire to a pattern matrix having reference data, which reference data show the γ table to be referred to in response to the matrix having the plurality and of dots γ to restrict on near fect and the
- 8. A color electrophotographic apparatus according to claim 7, wherein a partial everlap exists in the reference data provided within the pattern matrix, and a single y table is referred to by the plurality of edots within the pattern matrix.

- 9. Admethodrof processing antimage of color electro-photography by utilization of a plurality of color-fon-ers and by expressing halftone of feach color through use of halftone spots formed from a plurality of dots, said method comprising: 1 1882 and plurality of dots, said method comprising: 1 1882 and plurality of dots and plurality of dots.
 - a halftone processing process, in which halftone data are provided for respective colors
 and the image reproduction data corresponding to the dots are produced on the basis of the
 halftone data by reference to a conversion table
 to defining the correspondence between the halfand image reproduction process; in which a
 condition data is provided and the toners are
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 caused to adherento and developments region
 prowhose rarea and location correspond to the
 image reproduction data, within the dots;
 - entitles and bus also notices and bus and be another and bus a

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- 10. A method of processing an image of color electrophotography by utilization of a plurality of color tonersTand by expressing shalftone of each colors sat through:use:of halftone spots formed from a plural provided the spots formed from the spots formed ityoof, dots, said, method comprising noticed with its an ever pilist to the pulse-width modulation section 68 of the bilder halftoner processing process, bins which half are to statione data of respective colors are provided and square -vilithesimage seproduction data corresponding to a final the dots are reproduced on the basis offthe basis no halftone data by reference to a conversion table 2001 enidefining the correspondence between the half-Histone data and image reproduction data; and the factor ni ancimage reproduction process; in which a smil -ondrive signal corresponding to the image reproeraductionadataais/provided/and/atheatoners/ate/6/49 ⊕icaused to adhere to a developmento region 900 % -Mawhose kareay and alocation (correspond) to the discrete adjimage/reproduction/data/within the dots/scoop sold eviwherein, in the halftone processing process; make parthere sared prepared the simages reproductionic esta ള rdata to:be:ലsed-for-making distances:among അ ്
- 11. A-recording medium having recorded thereon an agent image processing program used for tausing a competitive puter to perform color electrophotographic image sold processing procedures for reproducing animage by a cutilization of applurality of colorationers and by a colorationers and by applurality of colorationers and by a colorationers and by a colorationers and by a colorationers and by a colorationers and colorationers are colorationers.

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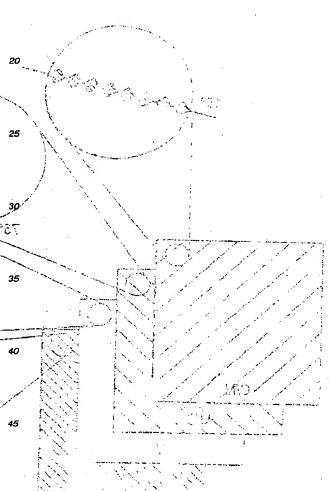
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image processing procedures comprising:

a halftone processing procedure, in which halftone data are provided for respective colors and the image reproduction data correspond- 5 ing to the dots are produced on the basis of the halftone data by reference to a conversion table defining the correspondence between the halftone data and image reproduction data, wherein the image reproduction data comprise data pertaining to a position and area to be exposed within the dot in the scanning direction of the beam, and the halftone processing procedures produces the image reproduction data to be used for changing an angle of at least one 15 color screen of a plurality of color screens to substantially an angle related to an irrational tangent.

12. A recording medium having recorded thereon an image processing program used for causing a computer to perform color electrophotographic image processing procedures for reproducing an image by utilization of a plurality of color toners and by expressing halftone of each color through use of halftone spots formed from a plurality of dots said image processing procedures comprising:

halftone processing procedures, in which halftone data of respective colors are provided and the image reproduction data corresponding to the dots are reproduced on the basis of the halftone data by reference to a conversion table defining the correspondence between the halftone data and image reproduction data, wherein the image reproduction data comprise data pertaining to a position and area to be exposed within the dot in a scanning direction of the beam, and the halftone processing procedures produces the image reproduction data to be used for making distances among the centroids of the halftone spots of the plurality of colors substantially equal.



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FIG. 1°

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FIG. 2

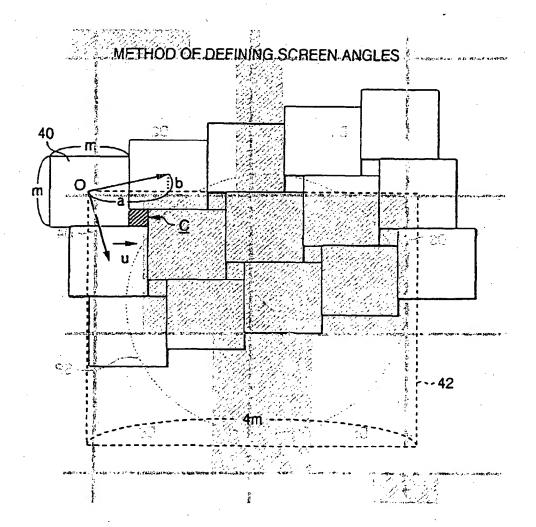
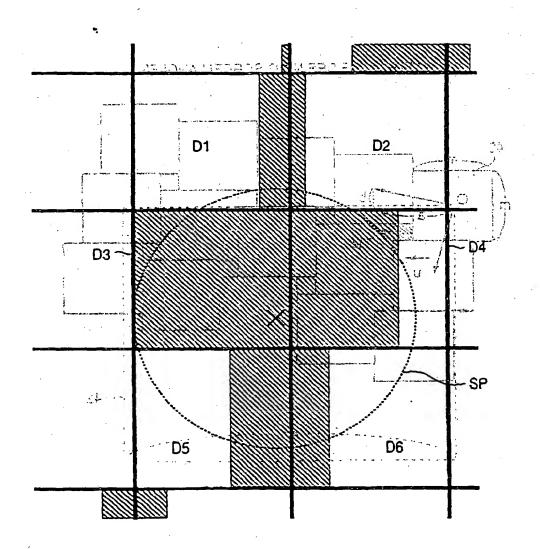
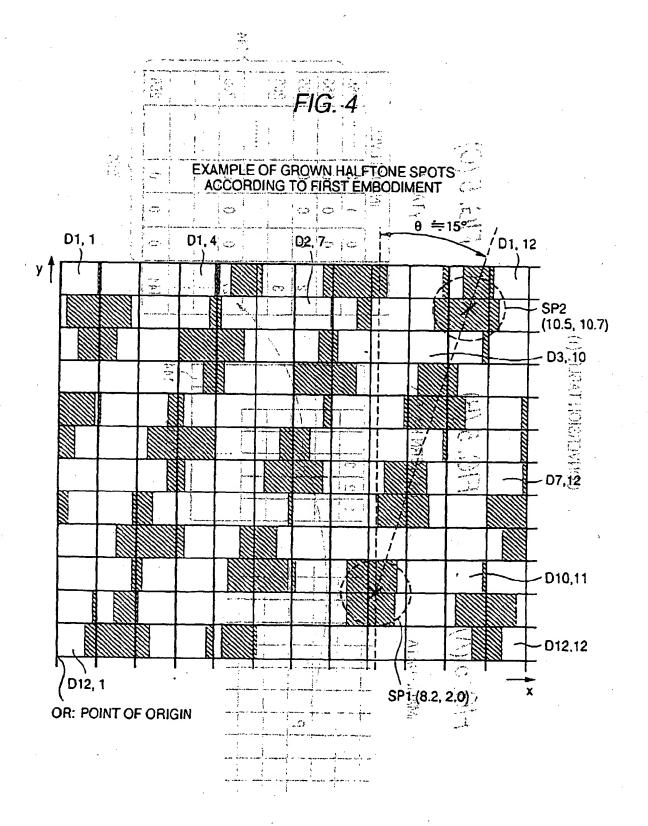


FIG. 3

EXAMPLE OF HALFTONE SPOT ACCORDING TO THE INVENTION





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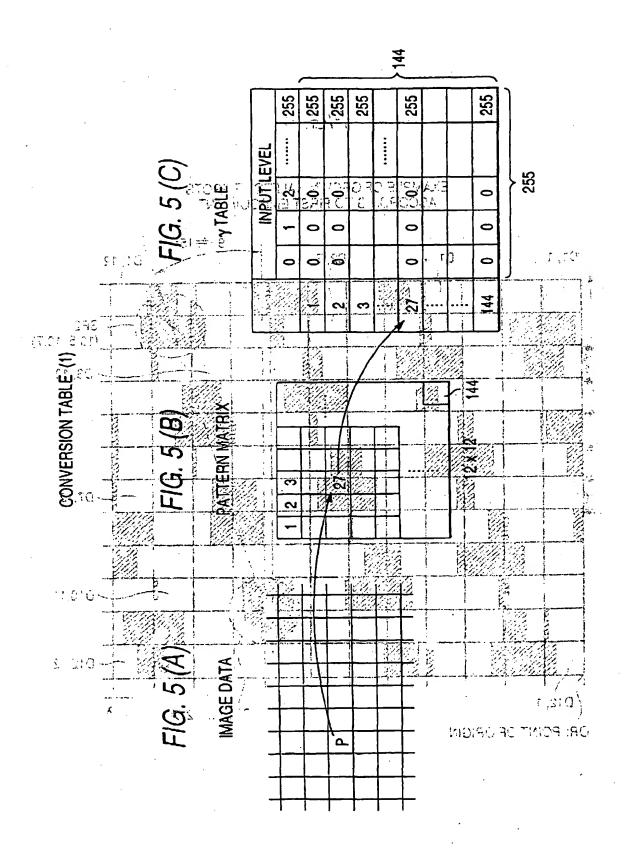


FIG. 6

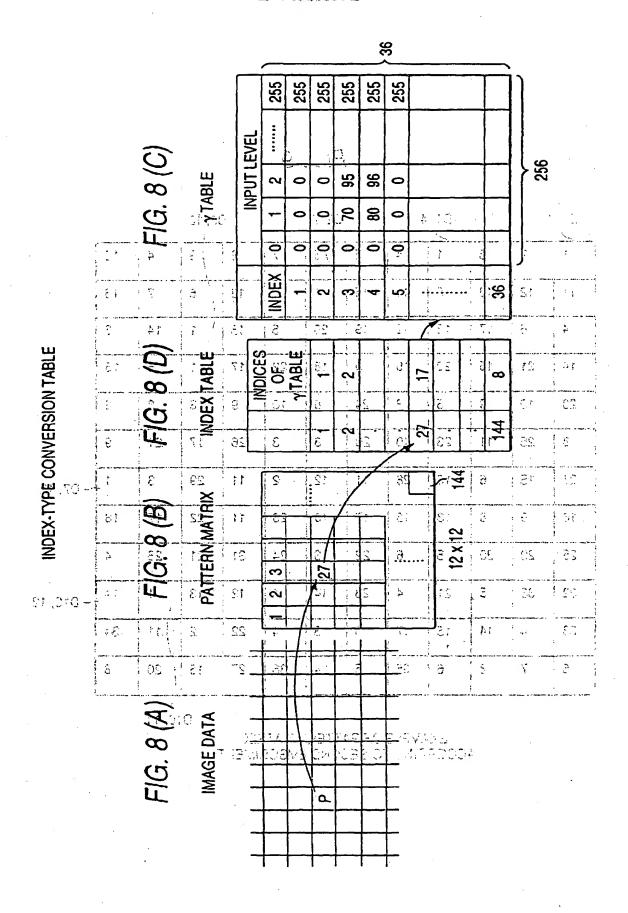
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EXAMPLE OF PATTERN MATRIX ACCORDING TO FIRST EMBODIMENT

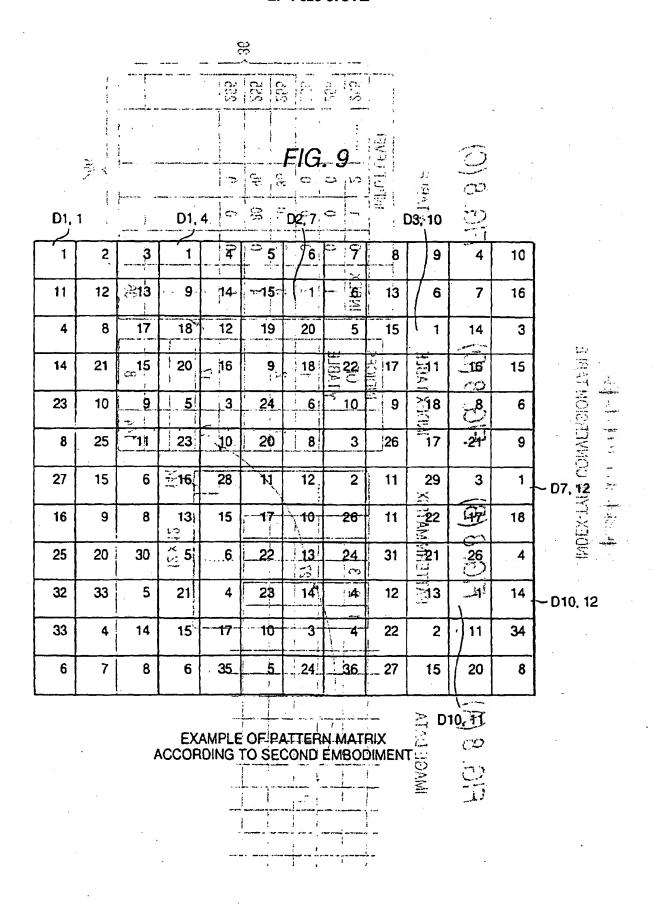
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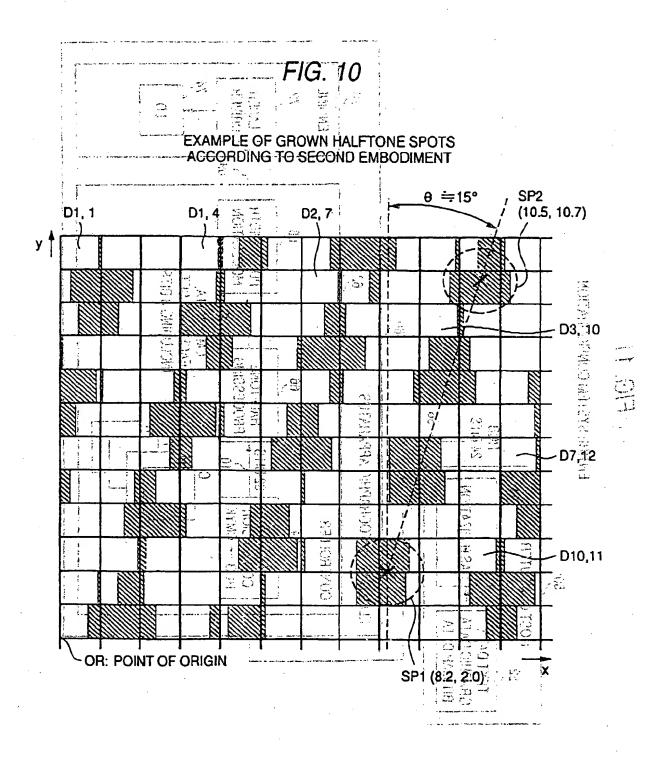
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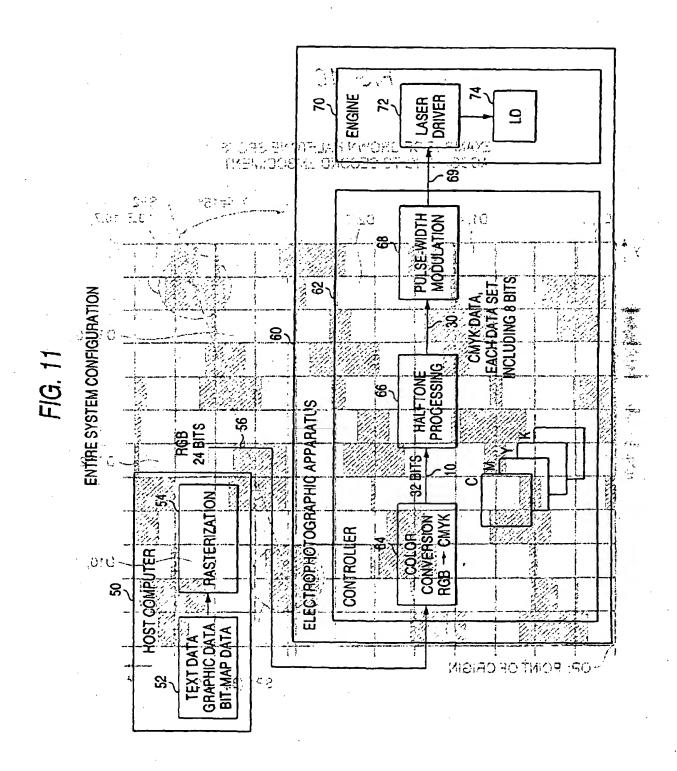
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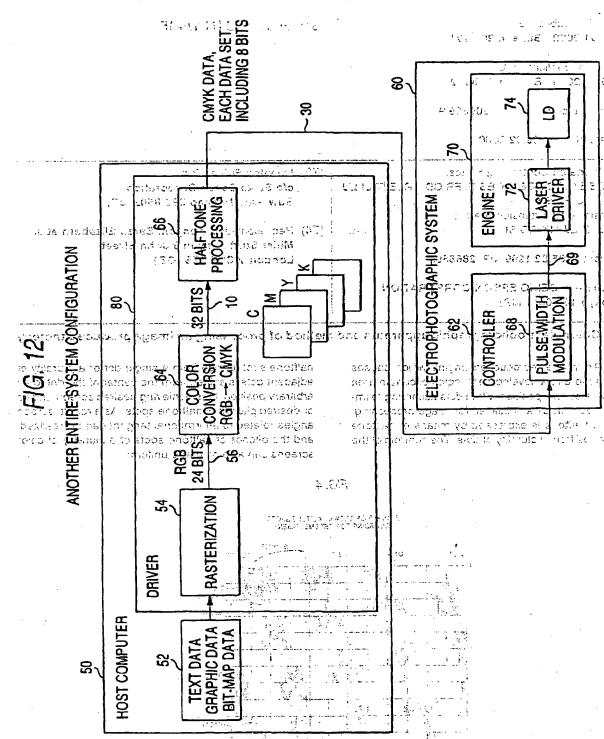
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EUROPEAN PATENT APPLICATION

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT-SE

Designated Extension States:
AL LT LV-MK-RO SI

(72). Inventor: Fujita, Toru, c/o Seiko Epson Gorporation Suwa-shi, Nagano 392-8502 (JP)

(74) Representative: Kenyon, Sarah Elizabeth et al Miller Sturt Kenyon 9 John Street London WC1N 2ES (GB)

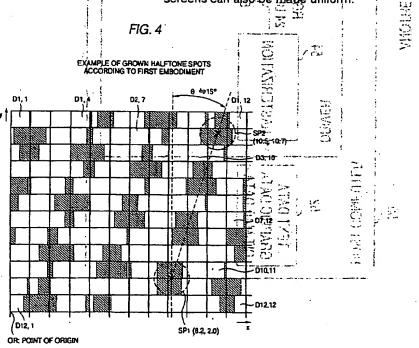
(71) Applicant: SEIKO EPSON CORPORATION
Tokyo 160-0811 (JP)

(30) Priority 305.02.1999 JP 2866699

(54) Color electrophotographic apparatus and method of processing an image produced thereby

(57) An image reproduction engine which causes toner to adhere to a development region of certain area located at a certain position within dots according to image reproduction data is utilized for image processing, wherein a halftone is expressed by means of halftone spots formed from a plurality of dots. The centroid of the

halftone spot formed from a single dot or a plurality of adjacent dots is shifted from the center of the dot to an arbitrary position, thus achieving desired screen angles or desired pitches of halftone spots. As a result, screen angles related to an irrational tangent can be realized, and the pitches of halftone spots of a plurality of color screens can also be made uniform.



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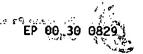
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